



UAS Integration in the NAS: Detect and Avoid

Conrad Rorie *for*

Jay Shively

Detect and Avoid

Sub-Project Manager





UAS-NAS Phase 2

Project Organization Structure

PROJECT OFFICE
LEVEL

Project Leadership

Project Manager (PM) Robert Sakahara, AFRC
Deputy PM Davis Hackenberg, AFRC
Chief Engineer (CE) William Johnson, LaRC

Project Support

Sr. Advisor Chuck Johnsons, AFRC
Staff Engineer Dan Roth, AFRC
Lead Resource Analyst April Jungers, AFRC
Resource Analysts Amber Gregory, AFRC
Warcquel Frieson, ARC
Julie Blackett, GRC
Pat O'Neal, LaRC
Scheduler Irma Ruiz, AFRC
Risk Manager/Outreach Jamie Turner, AFRC
Change/Doc. Mgmt Lexie Brown, AFRC
Admin Support Sarah Strahan, AFRC

Project Systems Engineering Office

Deputy Chief Engineer Clint St. John, AFRC
SIO Technical Manager Kurt Swieringa, LaRC

SUBPROJECT
LEVEL

Command and Control (C2)

Subproject Manager
Mike Jarrell, GRC
Subproject Technical Lead
Jim Griner, GRC

Detect and Avoid (DAA)

Subproject Manager
Jay Shively, ARC
Subproject Technical Lead
Gilbert Wu (A)/Confesor Santiago, ARC; Lisa Fern; ARC; Tod Lewis, LaRC

Integrated Test and Evaluation (IT&E)

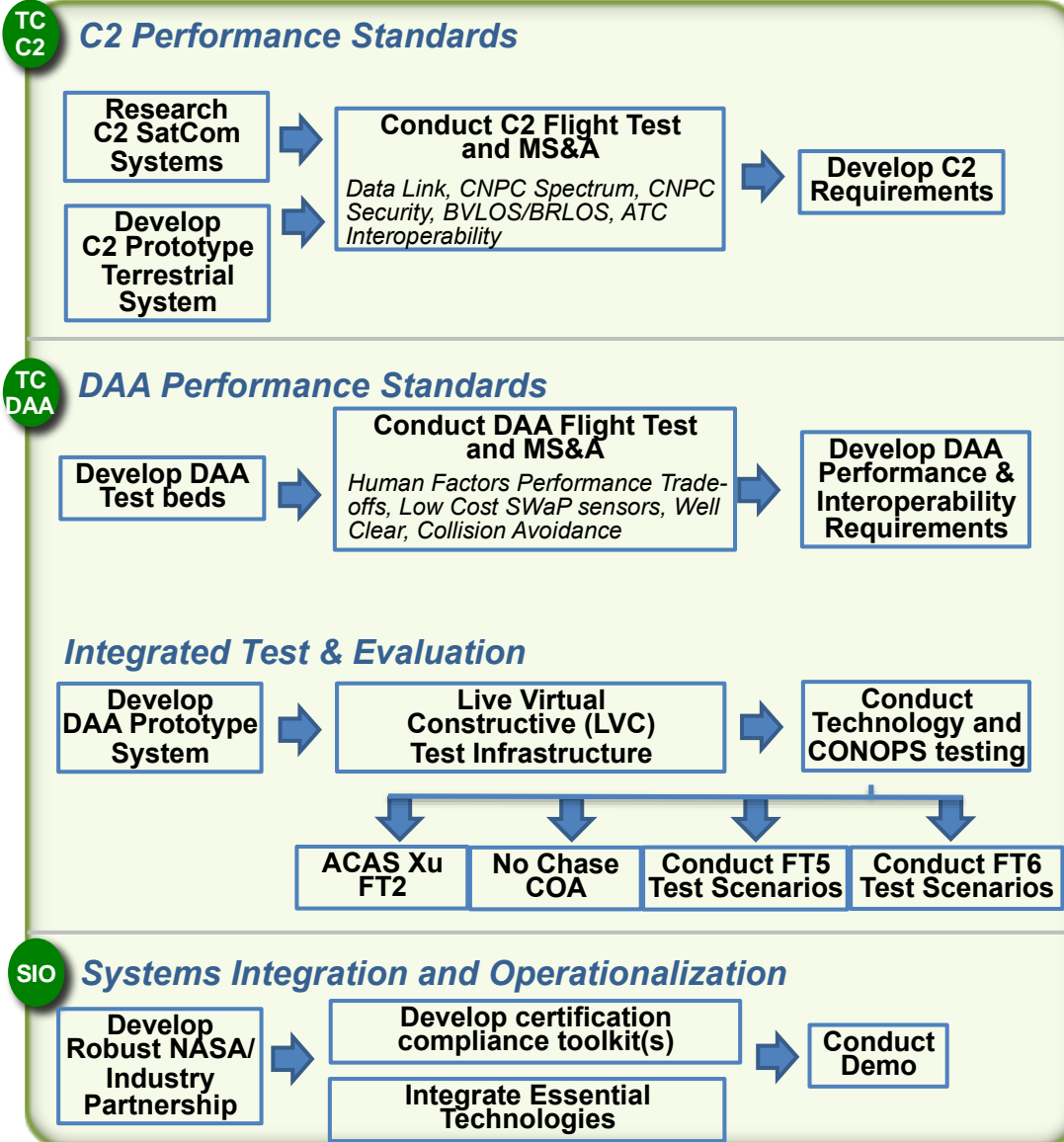
Subproject Manager
Mauricio Rivas, AFRC / Jim Murphy, ARC
Subproject Technical Lead
Ty Hoang, ARC (A) ; Sam Kim, AFRC

(A) Acting



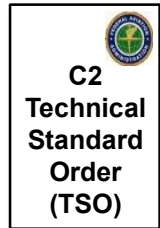
UAS-NAS Project Value Proposition

NASA UAS-NAS Project Activities



Key Products Resultant Outcomes

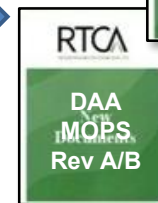
C2 Performance Requirements to inform C2 MOPS



DAA Performance Requirements to inform DAA MOPS



Re-usable Test Infrastructure



Substantiated path





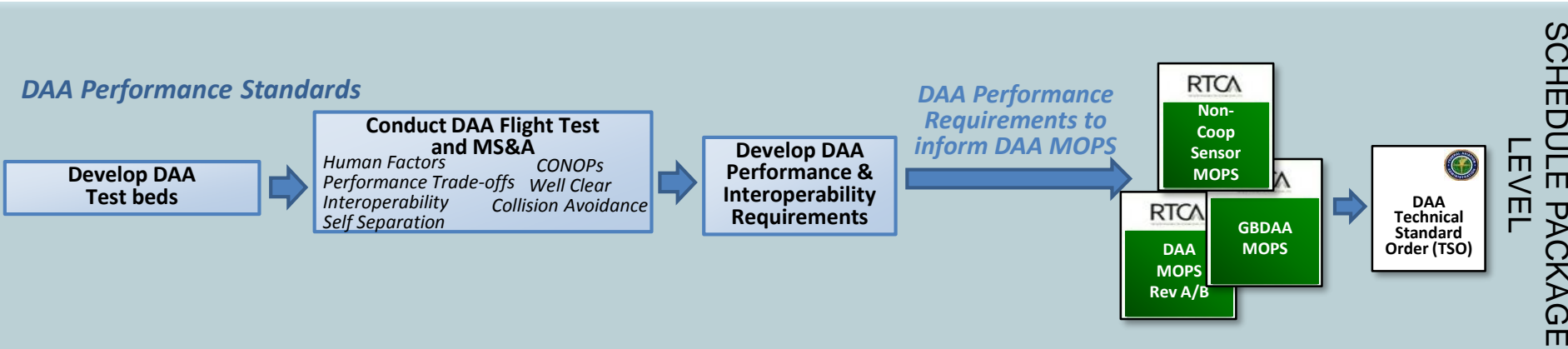
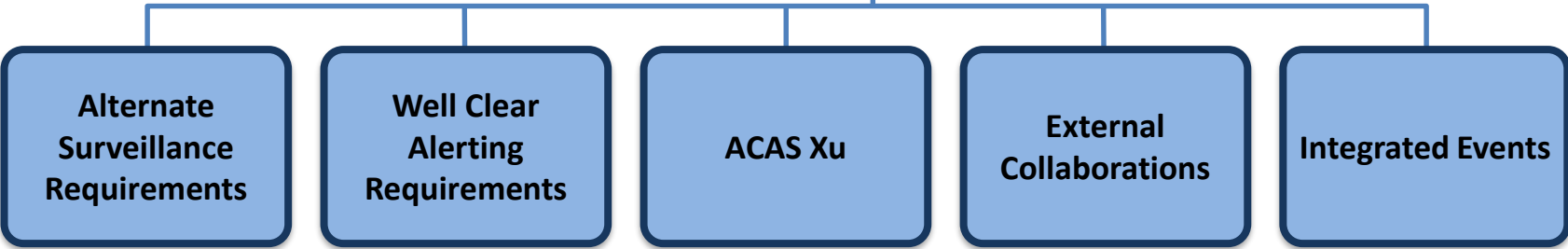
DAA Subproject Structure for Project Phase 2

TECHNICAL CHALLENGE/
SUBPROJECT LEVEL

TECHNICAL WORK PACKAGE LEVEL

SCHEDULE PACKAGE LEVEL

Detect and Avoid
<TC-DAA>
Subproject Manager (SPM)
Jay Shively, ARC
Subproject Technical Leads
Gilbert Wu (A), ARC; Lisa Fern, ARC; Tod Lewis, LaRC





General. When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to **see and avoid** other aircraft. When a rule of this section gives another aircraft the right-of-way, the pilot shall give way to that aircraft and may not pass over, under, or ahead of it unless **well clear**.

Piloted “see and avoid” => UAS “detect and avoid”

Pilot vision => surveillance sensors (on- or off- board, or both)

Pilot judgment of well clear => mathematical expression of well clear

Phase 1 DAA well clear defined as:

Horz Miss Distance = 4000ft

Vert Miss Distance = 450ft

modTau = 35sec

DMOD = 4000ft



DAA Operational Environments

Legend

Current Research Areas (FY14- FY16)

Proposed Research Areas (FY17 – FY20)

60K' MSL

18K' MSL

10K' MSL

MINIMUM ENROUTE
ALTITUDE

DAA System for Transition
to Operational Altitude
(> 10kft MSL)

500' AGL

UTM

Terminal Area Ops

Ground Based
Radar

GBSAA Data

UAS Ground
Control Station

HALE aircraft

Cooperative
Traffic

Airborne
Radar

Non-cooperative
Aircraft

Alternative
DAA Sensors
ACAS Xu

"Tweener"
UAS

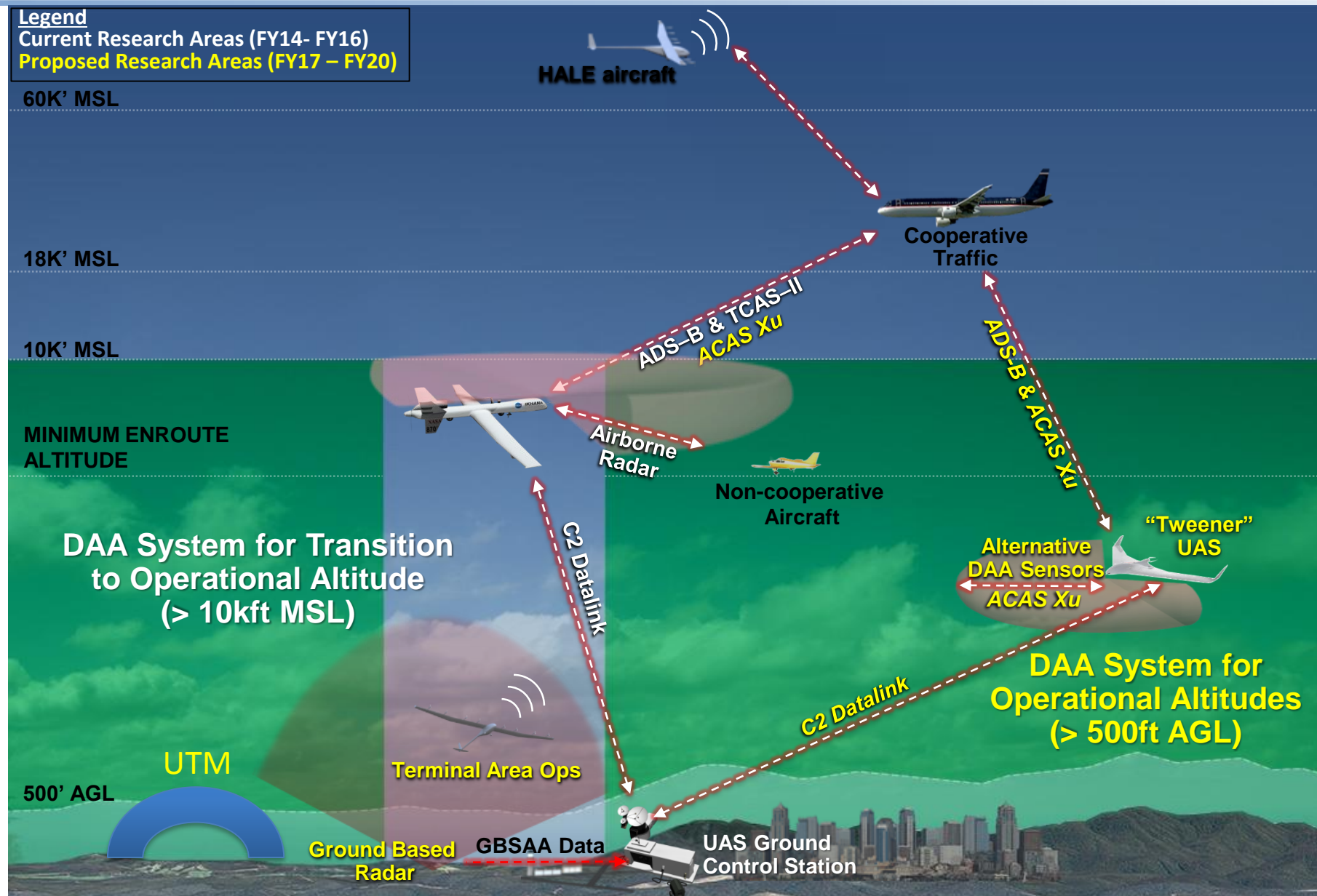
DAA System for
Operational Altitudes
(> 500ft AGL)

ADS-B & TCAS-II
ACAS Xu

ADS-B & ACAS Xu

C2 Datalink

C2 Datalink





Phase 1 Accomplishments

RTCA DO-365:

- Minimum Operating Performance Standards for **Detect and Avoid Systems**

RTCA DO-366:

- Minimum Operating Performance Standards for **Air-to Air Radar Traffic Surveillance**

FAA Technical Standard Orders:

- TSO-C211, Detect and Avoid
- TSO-C212, ATAR for Traffic Surveillance

NASA DAA Team Contributions:






- Well clear definition
- Alerting
- Guidance
- Displays
- Reference algorithm
- Significant modeling and simulation



- Augmented Well Clear Definitions
 - Terminal
 - Low SWaP
- Low SwaP Sensors
 - RADAR
 - Cooperative agreement with Honeywell
- Flight Tests
 - FY 19 – Low SWaP RADAR
 - Unmitigated encounters
 - FY 20 – Pilot response to new well clear definition; use of Low SWaP RADAR



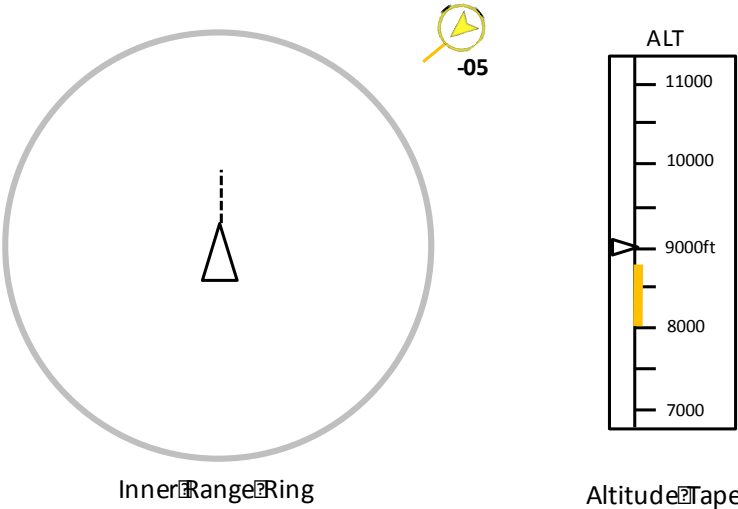
Phase 1 DAA Alerting

Symbol	Name	Pilot Action	DAA Well Clear Criteria	Time to Loss of DAA Well Clear	Aural Alert Verbiage
	Warning Alert	<ul style="list-style-type: none">Notify ATC as soon as practicable after taking action	DMOD = 0.66 nmi HMD = 0.66 nmi ZTHR = 450 ft modTau = 35 sec	25 sec	"Traffic, Maneuver Now" x2
	Corrective Alert	<ul style="list-style-type: none">Coordinate with ATC to determine an appropriate maneuver	DMOD = 0.66 nmi HMD = 0.66 nmi ZTHR = 450 ft modTau = 35 sec	55 sec	"Traffic, Avoid"
	Preventive Alert	<ul style="list-style-type: none">On current course, corrective action should not be required	DMOD = 0.66 nmi HMD = 0.66 nmi ZTHR = 700 ft modTau = 35 sec	55 sec	"Traffic, Monitor"
	Guidance Traffic	<ul style="list-style-type: none">Traffic generating guidance bands outside of current course	Associated w/ bands outside current course	X	N/A
	Remaining Traffic	<ul style="list-style-type: none">Traffic within sensor range	Within surveillance field of regard	X	N/A

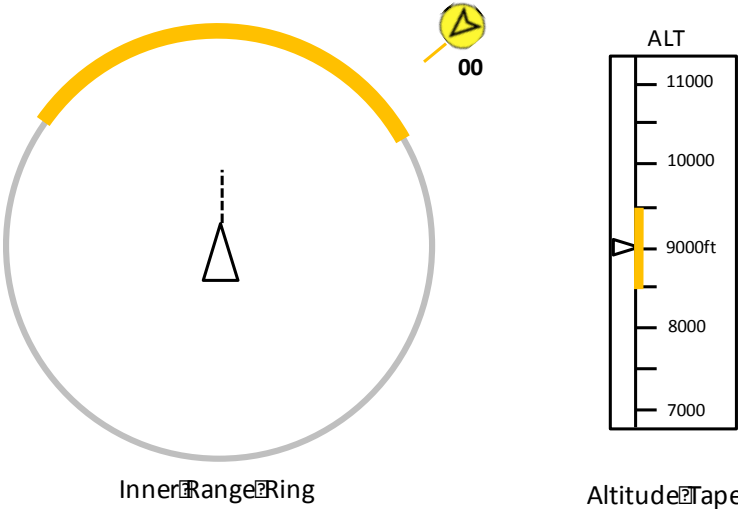


Phase 1 DAA Suggestive Maneuver Guidance

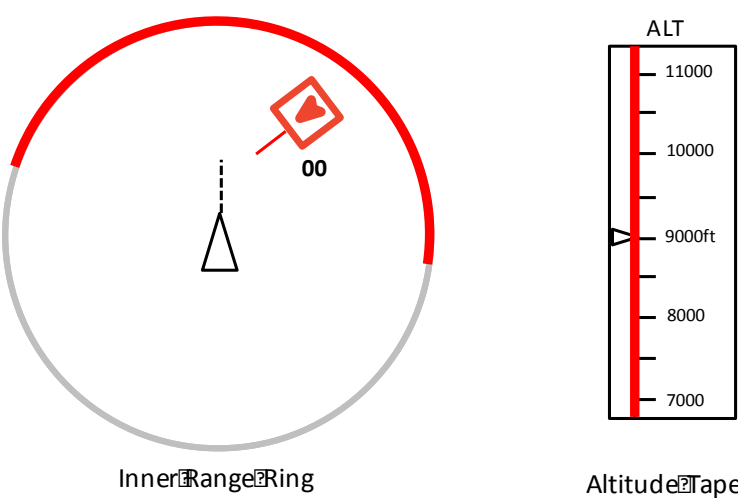
Remain DAA Well Clear Corrective Guidance



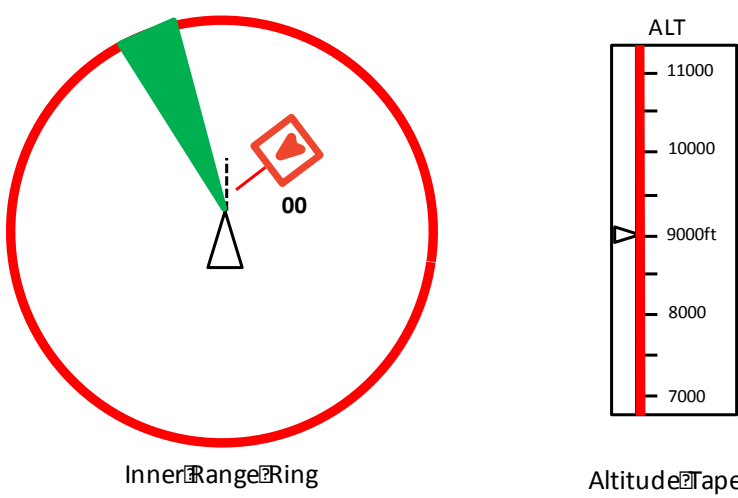
Remain DAA Well Clear Corrective Guidance



Remain DAA Well Clear Warning Guidance



Regain DAA Well Clear Guidance





HSI DAA Performance Metrics

- Multiple human-in-the-loop (HITL) simulations were performed to identify requirements for UAS DAA systems. The following metrics were used to assess pilot and system performance:
 - Pilot response times
 - Proportion of losses of DAA well clear
 - Severity of losses of DAA well clear
 - ATC interoperability
 - Subjective assessment & workload

Pilot-Air Traffic Control Interaction Timeline & Metrics

